Special Report

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Preoperative Testing in Asymptomatic Patients Undergoing Low- or Intermediate-Risk Noncardiac Surgery: A Scoping Review

HEALTH QUALITY ONTARIO

CONTEXT

Doing tests before elective (non-urgent) surgery may help physicians determine whether patients are fit for anesthesia and identify patients who are at higher risk of perioperative adverse events (complications just before, during, or just after surgery). However, patients often undergo routine preoperative testing because physicians believe testing will improve outcomes and safety. This practice of nonselective routine preoperative testing (testing everyone, regardless of risk) has been debated because of concerns about costs and use of resources, given that the benefits are uncertain.

OBJECTIVE

To provide an overview of systematic reviews, health technology assessments, and guidelines on the following preoperative tests:

- Laboratory testing for asymptomatic patients undergoing low-risk noncardiac surgery.
- Electrocardiograms for asymptomatic patients undergoing low-risk noncardiac surgery.
- Chest x-rays for asymptomatic patients undergoing low- to intermediate-risk noncardiac surgery.
- Resting echocardiography for asymptomatic patients undergoing low- to intermediate-risk noncardiac surgery.
- Cardiac stress testing for asymptomatic patients undergoing low- to intermediate-risk noncardiac surgery.

CONCLUSION

The evidence on preoperative testing for asymptomatic patients who are having low- to intermediate-risk noncardiac surgery was limited in both quantity and quality, but it consistently showed no benefit. Clinical guidelines recommend that health care providers consider patients' clinical risk factors when deciding whether or not to use preoperative testing.

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ACKNOWLEDGEMENTS

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Choosing Wisely Canada is a national campaign that aims to help physicians and patients engage in informative conversations about tests, treatments, and procedures, and help physicians and patients make smart and effective choices to ensure high-quality care. It will support physicians as they work with patients to ensure they not only get the care they need, but avoid tests, treatments, and procedures that have no value and could cause them harm.

As part of this campaign, Health Quality Ontario (HQO) has developed rigorous, evidence-based reviews of tests, treatments, and/or procedures that may be overused. Choosing Wisely Canada has made recommendations based on the evidence provided by HQO. These recommendations are available on the Choosing Wisely Canada website.

Citation

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BACKGROUND

Doing tests before elective (non-urgent) surgery may help physicians determine whether patients are fit for anesthesia and identify patients who are at higher risk of perioperative adverse events (complications just before, during, or just after surgery).[1] In patients who are at high risk, surgery may be delayed or medical management may be altered to reduce the risk of adverse events. However, patients often undergo routine preoperative testing because physicians believe testing will improve outcomes and safety, and lead to fewer adverse events. This practice of nonselective routine preoperative testing (testing everyone, regardless of risk) has been debated. Studies have shown that it may not be of benefit to patients if the potential harms from false positives and over-testing are considered.[2-5] There are also concerns about costs and use of resources if the benefits are uncertain.

Health Quality Ontario received a request from Choosing Wisely Canada to review the clinical effectiveness of five preoperative tests in asymptomatic adult patients who are undergoing low- to intermediate-risk noncardiac surgery. We undertook a scoping review to assess the literature on preoperative testing for the population of interest. Scoping reviews have been used more and more often to address a demand for timely summaries related to broad or complex research questions, or when the literature is vast or diverse.[6-8] They are ideal for providing an exploratory evaluation of the body of literature and identifying knowledge gaps. Here, we present the results of a scoping review[9] that aims to map the relevant literature by selecting, collecting, and summarizing existing knowledge.

OBJECTIVE

To provide an overview of systematic reviews, health technology assessments, and guidelines on the following preoperative tests:

- Laboratory testing (complete blood count, coagulation testing, or serum biochemistry) for asymptomatic patients undergoing low-risk noncardiac surgery.
- Electrocardiograms for asymptomatic patients undergoing low-risk noncardiac surgery.
- Chest x-rays for asymptomatic patients undergoing low- to intermediate-risk noncardiac surgery.
- Resting echocardiography for asymptomatic patients undergoing low- to intermediate-risk noncardiac surgery.
- Cardiac stress testing for asymptomatic patients undergoing low- to intermediate-risk noncardiac surgery.

METHODS

Information Sources

We conducted a focused literature search of the Cochrane Database of Systematic Reviews, Centre for Reviews and Dissemination databases, PubMed, and databases from Canadian and international health technology assessment agencies to identify relevant systematic reviews, health technology assessments, and guidelines.

We searched titles and abstracts using the following search phrase:

> ((pre-operat* preoperat* or pre-an?esthe* or prean?esthe* or pre-surg* or presurg*or peri-operat* or perioperat*) adj3 (screen* or assess* or check* or work-up* or consultat* or management* or evaluat* or test* or question* or predict*))

We also searched the following Canadian and international guideline databases using the search phrase described above:

- CMA Infobase (Canada) (www.cma.ca/En/Pages/clinical-practice-guidelines.aspx)
- Institute for Clinical Systems Improvement (United States) (www.icsi.org/guidelines__more/)
- National Guideline Clearinghouse (United States) (www.guideline.gov)
- National Health and Medical Research Council Clinical Practice Guidelines Portal (Australia) (www.clinicalguidelines.gov.au/)
- National Institute for Health and Care Excellence (United Kingdom) (guidance.nice.org.uk/index.jsp?action=find)
- Scottish Intercollegiate Guidelines Network (Scotland) (www.sign.ac.uk/guidelines/index.html)

We searched the following websites to identify any further relevant guidelines or recommendations:

- American College of Surgeons (www.facs.org)
- American Society of Anesthesiologists (www.asahq.org)
- Association of Anaesthetists of Great Britain and Ireland (www.aagbi.org)
- Australian Society of Anaesthetists (www.asa.org.au)
- Canadian Anesthesiologists' Society (www.cas.ca)
- Canadian Society of Internal Medicine (www.csim.ca)
- Choosing Wisely (United States) (www.choosingwisely.org)
- Choosing Wisely Australia (www.choosingwisely.org.au)
- Choosing Wisely Canada (www.choosingwiselycanada.org)
- European Society of Anaesthesiology (www.esahq.org)
- Scandinavian Society of Anaesthesiology and Intensive Care Medicine (www.ssai.info)

Finally, we examined reference lists for any additional relevant studies not identified through the search. All searches were limited to English-language documents published between January 1, 2005, and June 18, 2015.

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Eligibility Criteria

Types of Studies

We included relevant systematic reviews, health technology assessments, or guidelines that addressed the population and interventions of interest and had been published within the past 10 years. We excluded individual studies such as observational or randomized controlled trials, as well as nonsystematic reviews or systematic reviews that did not present results by type of preoperative test.

Population

The population of interest was asymptomatic adults (≥ 18 years of age) undergoing elective low- and/or intermediate-risk noncardiac surgery as defined in the study.

Interventions

Preoperative tests of interest were:

- Laboratory testing (complete blood count, coagulation testing, or serum biochemistry)
- Electrocardiograms
- Chest x-rays
- Resting echocardiography
- Cardiac stress testing

Outcomes

Outcomes were not prespecified a priori as an eligibility criterion.

Data Abstraction

A single reviewer examined each of the five topics and independently abstracted data from the publications included in this scoping review.* Recommendations from Choosing Wisely Canada and Choosing Wisely (USA) were abstracted. For health technology assessments and systematic reviews, we reported on the objectives, literature search time frame, population, interventions, comparators, outcomes, conclusions, and recommendations, where applicable. For guidelines, we also abstracted the recommendation, level of evidence, and level of recommendation. We abstracted recommendations in which it was unclear whether patients were asymptomatic or not. We excluded recommendations that explicitly mentioned high-risk surgery.

*Material quoted from published reports has been copy edited to ensure a consistent style.

RESULTS

Preoperative Laboratory Testing

Choosing Wisely Recommendations

We identified two recommendations relevant to preoperative laboratory testing (Table 1).

Table 1: Choosing Wisely Recommendations—Preoperative Laboratory Testing

Choosing Wisely	Society	Statement
Choosing Wisely Canada, 2014[10]	Canadian Association of Pathologists	Avoid routine preoperative laboratory testing for low-risk surgeries without a clinical indication
Choosing Wisely (USA), 2013[11]	American Society of Anesthesiologists	Don't obtain baseline laboratory studies in patients without significant systemic disease (ASA I or II) undergoing low-risk surgery—specifically complete blood count, basic or comprehensive metabolic panel, coagulation studies when blood loss (or fluid shifts) is/are expected to be minimal

Abbreviation: ASA, American Society of Anesthesiologists.

Systematic Reviews and/or Health Technology Assessments

We identified four systematic reviews, all of which reached similar conclusions on the effect of various types of preoperative laboratory testing in patients undergoing low-risk noncardiac surgery (Table 2).[1,12-14] Further details are provided in Appendices 1 and 2.

Table 2: Systematic Reviews—Preoperative Laboratory Testing

Author, Year	Preoperative Test	Conclusion(s)
Agency for Healthcare Research and Quality, 2014[1]	Routine testing (ECG, basic metabolic panel, and CBC)	There was no evidence of different outcomes related to routine preoperative testing before cataract surgery
	Preoperative testing (ECG, chest x-ray, basic and extended metabolic panels, CBC, coagulation tests, and urinalysis)	There was insufficient evidence regarding the impact of preoperative testing before general surgeries on perioperative complications, the rate of perioperative death, return to the operating room, prolonged hospital stay, or surgical cancellation or delay
	Preoperative testing (ECG, chest x-ray, basic and extended metabolic panels, CBC, coagulation tests, and urinalysis)	There was insufficient evidence regarding the comparison of routine versus per-protocol preoperative testing in adults undergoing orthopaedic surgery
Johansson et al, 2013[12]	Test grids	There was no evidence derived from high-quality studies that supported routine preoperative testing using test grids in healthy adults undergoing noncardiac surgery
	Hemoglobin and hematocrit	No studies were identified with a controlled comparison between preoperative testing and no testing for hemoglobin and hematocrit
	White blood cell count and CRP testing	There was no valid evidence supporting routine (nonselective) preoperative white blood cell count or CRP testing in asymptomatic patients
	Hemostasis testing	There was no valid evidence suggesting that routine preoperative hemostasis testing would lead to a change in clinical management or outcome in asymptomatic patients
	Renal function tests, electrolytes, and urine analysis	There was no evidence that justified routine testing for renal function, electrolytes, or urine analysis in asymptomatic subjects without a history of renal disease or electrolyte disorder
	Liver function testing	There was no valid evidence supporting routine (nonselective) liver tests in asymptomatic patients
Czoski-Murray et al, 2012[13]	Complete blood count	The evidence relating to the value of routine preoperative CBC for ASA grade 1 or 2 patients undergoing elective minor to intermediate surgery was limited in both quantity and quality
	Electrolytes and renal function	The evidence relating to the value of routine electrolytes and renal function for ASA grade 1 or 2 patients undergoing elective minor to intermediate surgery was limited in both quantity and quality
Keay et al, 2012[14]	Preoperative testing (ECG, chest x-ray, CBC, and various serum measurements)	Preoperative medical testing did not reduce the rate of intraoperative or postoperative medical adverse events (compared to selective or no testing) after cataract surgery

Abbreviations: ASA, American Society of Anesthesiologists; CBC, complete blood count; CRP, C-reactive protein; ECG, electrocardiogram.

Evidence-Based Guidelines

We identified eight guidelines that made recommendations relating to preoperative laboratory testing (Table 3).[15-22]

Table 3: Existing Guidelines—Preoperative Laboratory Testing

Guideline	Test	Recommendation	Level of Evidence	Level of Recommendation
Canadian Anesthesiologists' Society, 2015[15]	Complete blood count	Suggested indication: • Major surgery requiring group and screen or group and match • Chronic cardiovascular, pulmonary, renal, or hepatic disease • Malignancy • Known or suspected anemia, bleeding diathesis, or myelosuppression • Patient less than 1 year of age	Not reported	Not reported
	Bleeding and coagulation tests	Suggested indication for INR and APTT: • Anticoagulant therapy • Bleeding diathesis • Liver disease	Not reported	Not reported
	Electrolytes and renal function	Suggested indication: • Hypertension • Renal disease • Diabetes • Pituitary or adrenal disease • Digoxin or diuretic therapy, or other drug therapies affecting electrolytes	Not reported	Not reported
American Society for Gastrointestinal Endoscopy, 2014[16]	Complete blood count	We recommend against routine testing with coagulation studies, chest radiography, electrocardiography, blood typing or screening, hemoglobin or hematocrit levels, urinalysis, and chemistry tests before endoscopy in healthy patients. The use of these tests should be individualized based on patient and procedural risk factors	**GRADE level: high** Further research is very unlikely to change our confidence in the estimate of effect	Not reported
	Bleeding and coagulation tests	We suggest that coagulation studies be performed before endoscopy in patients with active bleeding, a known or clinically suspected bleeding disorder, medication risk (e.g., anticoagulant use, prolonged antibiotics), prolonged biliary obstruction, history of abnormal bleeding, malnutrition, or other conditions associated with acquired coagulopathies	**GRADE level: low** Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate	Not reported
		We suggest testing the hemoglobin/hematocrit before endoscopy in patients with pre-existing anemia or ongoing bleeding or when there is a high risk of significant blood loss during the procedure	**GRADE level: moderate** Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate	Not reported
		We suggest selective chemistry testing before endoscopy in patients with significant endocrine, renal, or hepatic dysfunction before using medications that may further impair function	**GRADE level: low** Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate	Not reported
Institute for	Complete blood	The reason to obtain a preoperative hemoglobin should be based on the	**GRADE level: low**	**Strong**

Guideline	Test	Recommendation	Level of Evidence	Level of Recommendation
Clinical Systems Improvement, 2014[17]	count	patient's underlying medical condition and the planned procedure. For example, patient has a history of anemia or history suggesting recent blood loss or anemia	Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change. The estimate or any estimate of effect is very uncertain	The work group feels that the evidence consistently indicates the benefit of this action outweighs the harms. This recommendation might change when higher-quality evidence becomes available
	Bleeding and coagulation tests	Coagulation studies should be performed in patients with a known history of anticoagulation abnormalities, patients with recent history suggesting the potential for anticoagulation problems, patients who are currently taking anticoagulant therapy, and patients who may need postoperative anticoagulation (where a baseline may be needed)	**GRADE level: low** Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change. The estimate or any estimate of effect is very uncertain	**Strong** The work group feels that the evidence consistently indicates the benefit of this action outweighs the harms. This recommendation might change when higher-quality evidence becomes available
	Electrolytes and renal function	Potassium should be measured in patients taking digoxin, diuretics, ACE inhibitors, or angiotensin receptor blockers	Not reported	Not reported
Société Française d'Anesthésie et de Réanimation (French Society of Anesthesia and Intensive Care), 2013[18]	Bleeding and coagulation tests	It is recommended that bleeding risk should be assessed based on personal and family history of hemorrhagic diathesis, and based on physical examination	**GRADE level: low** Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate	**Strong positive** Recommended
		A standardized questionnaire should probably be used to screen personal and family history for bleeding diathesis signs	**GRADE level: low** Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate	**Weak positive** Probably recommended or suggested
		It is recommended that hemostasis testing (PT, APTT, and platelet count) is not systematically requested in patients whose history and clinical examination results suggest no hemostatic disorders, regardless of ASA score, intervention type, and age (with the exception of children who are not yet walking)	**GRADE level: low** Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate	**Strong negative** Not recommended
		Hemostasis testing should not be systematically requested in patients whose history and clinical examination results suggest no hemostatic disorders, regardless of anesthesia type (general, central, peripheral, or combined), including [for] obstetric procedures	**GRADE level: low** Further research is very likely to have an important impact on our confidence in the estimate of effect	**Strong negative** Not recommended

Guideline	Test	Recommendation	Level of Evidence	Level of Recommendation
			and is likely to change the estimate	
		It is recommended to get specialist advice in cases where a history of bleeding diathesis suggests disrupted hemostatic function	**GRADE level: low** Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate	**Strong positive** Recommended
		Noninterviewable adults should probably undergo PT and APTT testing, as well as platelet count, so as to rule out certain inherited or acquired hemostatic disorders	**GRADE level: low** Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate	**Weak positive** Probably recommended or suggested
American Society of Anesthesiologists, 2012[19]	Complete blood count	Routine hemoglobin or hematocrit is not indicated. Clinical characteristics to consider as indications for such tests include type and invasiveness of procedure, patients with liver disease, extremes of age, and history of anemia, bleeding, and other hematologic disorders	**2** The literature contains noncomparative observational studies with associative (e.g., relative risk, correlation) or descriptive statistics	**B** Information from observational studies permits inference of beneficial or harmful relationships among clinical interventions and clinical outcomes
	Bleeding and coagulation tests	Clinical characteristics to consider for ordering selected coagulation studies include bleeding disorders, renal dysfunction, liver dysfunction, and type and invasiveness of procedure. The Task Force recognizes that anticoagulant medications and alternative therapies may present an additional perioperative risk. The Task Force believes that there were not enough data to comment on the advisability of coagulation tests before regional anesthesia	**2** The literature contains noncomparative observational studies with associative (e.g., relative risk, correlation) or descriptive statistics	**B** Information from observational studies permits inference of beneficial or harmful relationships among clinical interventions and clinical outcomes
	Electrolytes and renal function	Clinical characteristics to consider before ordering such tests [pre-anesthesia serum chemistries (e.g., potassium, glucose, sodium, renal and liver function studies)] include likely perioperative therapies, endocrine disorders, risk of renal and liver dysfunction, and use of certain medications or alternative therapies. The Task Force recognizes that laboratory values may differ from normal values at extremes of age	**2** The literature contains noncomparative observational studies with associative (e.g., relative risk, correlation) or descriptive statistics	**B** Information from observational studies permits inference of beneficial or harmful relationships among clinical interventions and clinical outcomes
Sociedade Brasileira de Cardiologia (Brazilian Society	Complete blood count	Complete blood count is recommended in patients with: • History of anemia or other hematologic diseases or liver diseases • When anemia is suspected during physical examination or when chronic diseases associated with anemia are present	**C** Evidence in very limited group of populations from consensus and experts' opinions, case reports, and	**I** Benefit >>> Risk; the treatment/procedure must be

Guideline	Test	Recommendation	Level of Evidence	Level of Recommendation
of Cardiology), 2011[20]		• Moderate/high-risk surgeries if a need for transfusion is anticipated	series	indicated/administered
		Complete blood count may help in: • All patients older than 40 years	**C** Evidence in very limited group of populations from consensus and experts' opinions, case reports, and series	**IIa** Benefit >> Risk; the choice for the treatment/procedure may help the patient
		Complete blood count is not recommended as: • Routine in asymptomatic individuals	**C** Evidence in very limited group of populations from consensus and experts' opinions, case reports, and series	**III** Risk > Benefit; the treatment/ procedure must not be performed since it does not help and may be harmful for the patient
	Bleeding and coagulation tests	Hemostasis/coagulation tests are recommended in patients with: • Patients on anticoagulation therapy • Patients with liver failure • Patients with coagulation disorders (history of bleeding) • Patients who will be submitted to intermediate- or high-risk surgeries	**C** Evidence in very limited group of populations from consensus and experts' opinions, case reports, and series	**I** Benefit >>> Risk; the treatment/procedure must be indicated/administered
		Hemostasis/coagulation tests are not recommended as: • Routine in asymptomatic individuals	**C** Evidence in very limited group of populations from consensus and experts' opinions, case reports, and series	**III** Risk > Benefit; the treatment/ procedure must not be performed since it does not help and may be harmful for the patient
	Electrolytes and renal function	Determination of serum creatinine is recommended in: • Patients with kidney disease, diabetes mellitus, hypertension, liver failure, heart failure, and whose serum creatinine has not been determined in the last 12 months • Patients who will be submitted to intermediate- or high-risk surgeries	**C** Evidence in very limited group of populations from consensus and experts' opinions, case reports, and series	**I** Benefit >>> Risk; the treatment/procedure must be indicated/administered
		Determination of serum creatinine may help in: • All patients older than 40 years	**C** Evidence in very limited group of populations from consensus and experts' opinions, case reports, and series	**IIa** Benefit >> Risk; the choice for the treatment/procedure may help the patient
		Determination of serum creatinine is not recommended as: • Routine in asymptomatic individuals	**C** Evidence in very limited group of populations from consensus and experts' opinions, case reports, and	**III** Risk > Benefit; the treatment/ procedure must not be performed

Guideline	Test	Recommendation	Level of Evidence	Level of Recommendation
			series	since it does not help and may be harmful for the patient
Società Italiana per lo Studio dell' Emostasi e della Trombosi (Italian Society for Hemostasis and Thrombosis), 2009[21]	Bleeding and coagulation tests	PT, APTT, and platelet count are considered appropriate before surgery both in adults and children, even in case of a negative bleeding history	**D** Expert consensus	Not reported
		The bleeding time is not considered appropriate before surgery or invasive procedures in adults or children	**D** Expert consensus	Not reported
		Fibrinogen, PFA-100 closure time, thromboelastography, and platelet aggregation test are not considered appropriate before surgery or invasive procedures in adults and children	**D** Expert consensus	Not reported
British Committee for Standards in Haematology, 2008[22]	Bleeding and coagulation tests	Routine coagulation testing to predict postoperative bleeding risk in unselected patients prior to surgery or other invasive procedures is not recommended	**Level III** Evidence obtained from well-designed nonexperimental descriptive studies, such as comparative studies, correlation studies, and case studies	**Grade B** Requires the availability of well conducted clinical studies but no randomized clinical trials on the topic of recommendation (evidence levels IIa, IIb, III)
		A bleeding history, including detail of family history, previous excessive post-traumatic or postsurgical bleeding and use of antithrombotic drugs should be taken in all patients preoperatively and prior to invasive procedures	**Level IV** Evidence obtained from expert committee reports or opinions and/or clinical experiences of respected authorities	**Grade C** Requires evidence obtained from expert committee reports or opinions and/or clinical experiences of respected authorities. Indicates an absence of directly applicable clinical studies of good quality (evidence level IV)
		If the bleeding history is negative, no further coagulation testing is indicated	**Level IV** Evidence obtained from expert committee reports or opinions and/or clinical experiences of respected authorities	**Grade C** Requires evidence obtained from expert committee reports or opinions and/or clinical experiences of respected authorities. Indicates an absence of directly applicable clinical studies of good

Guideline	Test	Recommendation	Level of Evidence	Level of Recommendation
				quality (evidence level IV)
		If the bleeding history is positive or there is a clear clinical indication (e.g., liver disease), a comprehensive assessment, guided by the clinical features, is required	**Level IV** Evidence obtained from expert committee reports or opinions and/or clinical experiences of respected authorities	**Grade C** Requires evidence obtained from expert committee reports or opinions and/or clinical experiences of respected authorities. Indicates an absence of directly applicable clinical studies of good quality (evidence level IV)

Abbreviations: ACE, angiotensin-converting enzyme; APTT, activated partial thromboplastin time; ASA, American Society of Anesthesiologists; GRADE, Grading of Recommendations Assessment, Development and Evaluation; INR, international normalized ratio; PFA-100, Platelet Function Analyzer-100; PT, prothrombin time.

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Preoperative Electrocardiograms

Choosing Wisely Recommendations

We did not identify any Choosing Wisely recommendations relevant to preoperative electrocardiograms. A few recommendations from Choosing Wisely Canada[23,24] and Australia[25] were in support of not performing electrocardiograms in asymptomatic patients. However, these recommendations were excluded because they were not specific to a preoperative patient population.

Systematic Reviews and/or Health Technology Assessments

We identified two systematic reviews that examined the effectiveness of preoperative electrocardiograms (Table 4).[1,14] Further details are provided in Appendices 1 and 2.

Table 4: Systematic Reviews—Preoperative Electrocardiograms

Author, Year	Preoperative Test	Conclusion(s)
Agency for Healthcare Research and Quality, 2014[1]	Routine testing (ECG, basic metabolic panel, and CBC)	There was no evidence of different outcomes related to routine preoperative testing before cataract surgery
	Preoperative testing (ECG, chest x-ray, basic and extended metabolic panels, CBC, coagulation tests, and urinalysis)	There was insufficient evidence regarding the impact of preoperative testing before general surgeries on perioperative complications, the rate of perioperative death, return to the operating room, prolonged hospital stay, or surgical cancellation or delay
	Preoperative testing (ECG, chest x-ray, basic and extended metabolic panels, CBC, coagulation tests, and urinalysis)	There was insufficient evidence regarding the comparison of routine versus per-protocol preoperative testing in adults undergoing orthopaedic surgery
Keay et al, 2012[14]	Preoperative testing (ECG, chest x-ray, CBC, and various serum measurements)	Preoperative medical testing did not reduce the rate of intraoperative or postoperative medical adverse events (compared to selective or no testing) after cataract surgery

Abbreviations: CBC, complete blood count; ECG, electrocardiogram.

Evidence-Based Guidelines

We identified nine guidelines that made recommendations relating to preoperative electrocardiograms (Table 5).[15-17,19,20,26-29]

Table 5: Existing Guidelines—Preoperative Electrocardiograms

Guideline	Recommendation	Level of Evidence	Level of Recommendation
Canadian Anesthesiologists' Society, 2015[15]	Laboratory investigations should be ordered only when indicated by the patient's medical status, drug therapy, or the nature of the proposed procedure. Investigations should not be ordered on a routine basis. Suggested indications for ECG: • Heart disease, diabetes, other risk factors for cardiac disease • Subarachnoid or intracranial hemorrhage, cerebrovascular accident, head trauma	Not reported	Not reported
American College of Cardiology/ American Heart Association, 2014[26]	Preoperative resting 12-lead ECG is reasonable for patients with known coronary heart disease, significant arrhythmia, peripheral arterial disease, cerebrovascular disease, or other significant structural heart disease, except for those undergoing low-risk surgery	**B** Limited populations evaluated. Data derived from a single randomized trial or nonrandomized studies	**IIa** Benefit >> Risk Additional studies with focused objectives needed. It is reasonable to perform procedure/administer treatment
	Preoperative resting 12-lead ECG may be considered for asymptomatic patients without known coronary heart disease, except for those undergoing low-risk surgery	**B** Limited populations evaluated. Data derived from a single randomized trial or nonrandomized studies	**IIb** Benefit ≥ Risk Additional studies with broad objectives needed; additional registry data would be helpful. Procedure/treatment may be considered
	Routine preoperative resting 12-lead ECG is not useful for asymptomatic patients undergoing low-risk surgical procedures	**B** Limited populations evaluated. Data derived from a single randomized trial or nonrandomized studies	**III** No benefit or harm *No benefit* • Procedure/test is not helpful • Treatment has no proven benefit *Harm* • Procedure/test has excess cost without benefit or is harmful • Treatment is harmful to patients
American Society for Gastrointestinal Endoscopy, 2014[16]	We recommend against routine testing with coagulation studies, chest radiography, ECG, blood typing or screening, hemoglobin or hematocrit levels, urinalysis, and chemistry tests before endoscopy in healthy patients. The use of these tests should be individualized based on patient and procedural risk factors	**GRADE level: high** Further research is very unlikely to change our confidence in the estimate of effect	Not reported

Guideline	Recommendation	Level of Evidence	Level of Recommendation
European Society of Cardiology/ European Society of Anaesthesiology, 2014[27]	Preoperative ECG is recommended for patients who have risk factor(s) and are scheduled for intermediate- or high-risk surgery	**C** Consensus of opinion of the experts and/or small studies, retrospective studies, registries	**I** Evidence and/or general agreement that a given treatment or procedure is beneficial, useful, effective
	Preoperative ECG may be considered for patients who have risk factor(s) and are scheduled for low-risk surgery	**C** Consensus of opinion of the experts and/or small studies, retrospective studies, registries	**IIb** Usefulness/efficacy is less well established by evidence/opinion
	Preoperative ECG may be considered for patients who have no risk factors, are above 65 years of age, and are scheduled for intermediate-risk surgery	**C** Consensus of opinion of the experts and/or small studies, retrospective studies, registries	**IIb** Usefulness/efficacy is less well established by evidence/opinion
	Routine preoperative ECG is not recommended for patients who have no risk factors and are scheduled for low-risk surgery	**B** Data derived from a single randomized clinical trial or large nonrandomized studies	**III** Evidence or general agreement that the given treatment or procedure is not useful/effective, and in some cases may be harmful
Institute for Clinical Systems Improvement, 2014[17]	Perform ECG for all patients age 65 and over, within 1 year prior to procedure	**GRADE level: low** Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change. The estimate or any estimate of effect is very uncertain	**Weak** The work group recognizes that there is significant uncertainty about the best estimates of benefits and harms
	ECGs are not indicated, regardless of age, for those patients having cataract surgery	**GRADE level: high** Further research is very unlikely to change our confidence in the estimate of effect	**Strong** The work group is confident that the desirable effects of adhering to this recommendation outweigh the undesirable effects. This is a strong recommendation for or against. This applies to most patients
	Preoperative ECGs are not recommended for patients undergoing other minimal-risk procedures, unless medical history/assessment indicate a high-risk patient	**GRADE level: high** Further research is very unlikely to change our confidence in the estimate of effect	**Strong** The work group is confident that the desirable effects of adhering to this recommendation outweigh the undesirable effects. This is a strong recommendation for or against. This applies to most patients
Feely et al, 2013[28]	The decision to perform preoperative testing should be based on the history and physical examination findings, perioperative risk assessment, and clinical judgment	**A** Consistent, good-quality, patient-oriented evidence	Not reported

Guideline	Recommendation	Level of Evidence	Level of Recommendation
	Patients with signs and symptoms of cardiovascular disease should undergo preoperative ECG	**C** Consensus, disease-oriented evidence, usual practice, expert opinion, or case series	Not reported
	Patients in their usual state of health who are undergoing cataract surgery do not require preoperative testing	**A** Consistent, good-quality, patient-oriented evidence	Not reported
American Society of Anesthesiologists, 2012[19]	Consideration of selected clinical characteristics may assist the anesthesiologist when deciding to order, require, or perform preoperative tests. Important clinical characteristics may include cardiocirculatory disease, respiratory disease, and type or invasiveness of surgery The Task Force recognizes that ECG abnormalities may be higher in older patients and in patients with multiple cardiac risk factors An ECG may be indicated for patients with known cardiovascular risk factors or for patients with risk factors identified in the course of a pre-anesthesia evaluation. Age alone may not be an indication for ECG	**2** The literature contains noncomparative observational studies with associative (e.g., relative risk, correlation) or descriptive statistics	**B** Information from observational studies permits inference of beneficial or harmful relationships among clinical interventions and clinical outcomes
Sociedade Brasileira de Cardiologia (Brazilian Society of Cardiology), 2011[20]	Requesting an ECG is recommended in: • Patients with a history and/or abnormalities on physical examination suggestive of cardiovascular disease • Patients with a recent episode of ischemic chest pain or considered to be at high risk after algorithmic assessment or according to the assistant physician • Patients with diabetes mellitus	**C** Evidence in very limited group of populations from consensus and experts' opinions, case reports, and series	**I** Benefit >>> Risk; the treatment/procedure must be indicated/administered
	Requesting an ECG may help in: • Obese patients • All patients older than 40 years	**C** Evidence in very limited group of populations from consensus and experts' opinions, case reports, and series	**IIa** Benefit >> Risk; the choice for the treatment/procedure may help the patient
	It is not recommended to: • Routinely request an ECG for asymptomatic individuals who will be submitted to low-risk surgeries	**C** Evidence in very limited group of populations from consensus and experts' opinions, case reports, and series	**III** Risk > Benefit; the treatment/procedure must not be performed since it does not help and may be harmful for the patient

Guideline	Recommendation	Level of Evidence	Level of Recommendation
American Society of Plastic Surgeons, 2009[29]	Order pertinent tests based on the patient's preoperative history and physical examination results: • ECG in patients older than 45 years • ECG at any age when known cardiac conditions are present • Complete blood count/blood chemistries, as needed, for detailed evaluation of specific diagnosis • Additional tests as appropriate	**V: Expert opinion** Expert opinion; case report or clinical example; or evidence based on physiology, bench research, or "first principles"	**D** Option Level V: little or no systematic empirical evidence Clinicians should consider all options in their decision-making and be alert to new published evidence that clarifies the balance of benefit versus harm; patient preference should have a substantial influencing role

Abbreviations: ECG, electrocardiogram; GRADE, Grading of Recommendations Assessment, Development and Evaluation.

Preoperative Chest X-rays

Choosing Wisely Recommendations

We identified two recommendations relevant to preoperative chest x-rays (Table 6).

Table 6: Choosing Wisely Recommendations—Preoperative Chest X-rays

Choosing Wisely	Society	Statement
Choosing Wisely Canada, 2014[30]	Canadian Society of Internal Medicine	Don't routinely perform preoperative testing (such as chest x-rays, echocardiograms, or cardiac stress tests) for patients undergoing low-risk surgeries
Choosing Wisely (USA), 2012[31]	American College of Radiology	Avoid admission or preoperative chest x-rays for ambulatory patients with unremarkable history and physical exam

Systematic Reviews and/or Health Technology Assessments

We identified three systematic reviews that examined the effectiveness of preoperative chest x-rays in patients undergoing low-risk noncardiac surgery (Table 7).[1,12,14] Further details are provided in Appendices 1 and 2.

Table 7: Systematic Reviews—Preoperative Chest X-rays

Author, Year	Preoperative Test	Conclusion(s)
Agency for Healthcare Research and Quality, 2014[1]	Preoperative testing (ECG, chest x-ray, basic and extended metabolic panels, CBC, coagulation tests, and urinalysis)	There was insufficient evidence regarding the impact of preoperative testing before general surgeries on perioperative complications, the rate of perioperative death, return to the operating room, prolonged hospital stay, or surgical cancellation or delay
	Preoperative testing (ECG, chest x-ray, basic and extended metabolic panels, CBC, coagulation tests, and urinalysis)	There was insufficient evidence regarding the comparison of routine versus per-protocol preoperative testing in adults undergoing orthopaedic surgery
Johansson et al, 2013[12]	Pulmonary evaluation (spirometry, chest x-ray, blood gases)	There was no valid evidence supporting routine (nonselective) chest x-ray
Keay et al, 2012[14]	Preoperative testing (ECG, chest x-ray, CBC, and various serum measurements)	Preoperative medical testing did not reduce the rate of intraoperative or postoperative medical adverse events (compared to selective or no testing) after cataract surgery

Abbreviations: CBC, complete blood count; ECG, electrocardiogram.

Evidence-Based Guidelines

We identified five guidelines that made recommendations relating to preoperative chest x-rays (Table 8).[15,16,19,20,28]

Table 8: Existing Guidelines—Preoperative Chest X-rays

Guideline	Recommendation	Level of Evidence	Level of Recommendation
Canadian Anesthesiologists' Society, 2015[15]	Laboratory investigations should be ordered only when indicated by the patient's medical status, drug therapy, or the nature of the proposed procedure. Investigations should not be ordered on a routine basis Suggested indications for chest radiograph: • Cardiac or pulmonary disease • Malignancy	Not reported	Not reported
American Society for Gastrointestinal Endoscopy, 2014[16]	We recommend against routine testing with coagulation studies, chest radiography, electrocardiography, blood typing or screening, hemoglobin or hematocrit levels, urinalysis, and chemistry tests before endoscopy in healthy patients. The use of these tests should be individualized based on patient and procedural risk factors	**GRADE level: high** Further research is very unlikely to change our confidence in the estimate of effect	Not reported
Feely et al, 2013[28]	The decision to perform preoperative testing should be based on the history and physical examination findings, perioperative risk assessment, and clinical judgment	**A** Consistent, good-quality, patient-oriented evidence	Not reported
	Patients with new or unstable cardiopulmonary signs or symptoms should undergo preoperative chest radiography	**C** Consensus, disease-oriented evidence, usual practice, expert opinion, or case series	Not reported
	Patients in their usual state of health who are undergoing cataract surgery do not require preoperative testing	**A** Consistent, good-quality, patient-oriented evidence	Not reported
American Society of Anesthesiologists, 2012[19]	Consideration of selected clinical characteristics may assist the anesthesiologist when deciding to order, require, or perform preoperative tests. Clinical characteristics to consider include smoking, recent upper respiratory infection, COPD, and cardiac disease The Task Force recognizes that chest radiographic abnormalities may be higher in such patients but does not believe that extremes of age, smoking, stable COPD, stable cardiac disease, or resolved recent upper respiratory infection should be considered unequivocal indications for chest radiography	**2** The literature contains noncomparative observational studies with associative (e.g., relative risk, correlation) or descriptive statistics	**B** Information from observational studies permits inference of beneficial or harmful relationships among clinical interventions and clinical outcomes
Sociedade Brasileira de Cardiologia (Brazilian Society of Cardiology), 2011[20]	Requesting a chest x-ray is recommended: • Patients with a history or diagnostic tests suggestive of cardiorespiratory diseases	**C** Evidence in very limited group of populations from consensus and experts' opinions, case reports, and series	**I** Benefit >>> Risk; the treatment/procedure must be indicated/administered
	Requesting a chest x-ray may help in: • Patients older than 40 years • Medium to major surgeries, mainly intra-thoracic and intra-abdominal surgeries	**C** Evidence in very limited group of populations from consensus and experts' opinions, case reports, and series	**IIa** Benefit >> Risk; the choice for the treatment/procedure may help the patient

Guideline	Recommendation	Level of Evidence	Level of Recommendation
	Requesting a chest x-ray is not recommended as: • Routine in asymptomatic individuals	**C** Evidence in very limited group of populations from consensus and experts' opinions, case reports, and series	**III** Risk > Benefit; the treatment/procedure must not be performed since it does not help and may be harmful for the patient

Abbreviations: COPD, chronic obstructive pulmonary disease; GRADE, Grading of Recommendations Assessment, Development and Evaluation.

Preoperative Resting Echocardiography

Choosing Wisely Recommendations

We identified three recommendations relevant to preoperative resting echocardiography (Table 9).

Table 9: Choosing Wisely Recommendations—Preoperative Resting Echocardiography

Choosing Wisely	Society	Statement
Choosing Wisely Canada, 2014[30]	Canadian Society of Internal Medicine	Don't routinely perform preoperative testing (such as chest x-rays, echocardiograms, or cardiac stress tests) for patients undergoing low-risk surgeries
Choosing Wisely (USA), 2013[11]	American Society of Anesthesiologists	Don't obtain baseline diagnostic cardiac testing (transthoracic/ esophageal echocardiography) or cardiac stress testing in asymptomatic stable patients with known cardiac disease (e.g., CAD, valvular disease) undergoing low- or moderate-risk noncardiac surgery
Choosing Wisely (USA), 2013[32]	American Society of Echocardiography	Avoid echocardiograms for preoperative/perioperative assessment of patients with no history or symptoms of heart disease

Abbreviation: CAD, coronary artery disease.

Systematic Reviews and/or Health Technology Assessments

We identified one systematic review that examined the effectiveness of preoperative resting echocardiography in patients undergoing low-risk noncardiac surgery (Table 10).[33] Further details are provided in Appendices 1 and 2.

Table 10: Systematic Review—Preoperative Resting Echocardiography

Author, Year	Preoperative Test	Conclusions
Health Quality Ontario, 2014[33]	Resting echocardiography	No studies were identified that examined the prognostic accuracy of resting echocardiography Very low-quality evidence demonstrated that resting echocardiography was not associated with improved survival or decreased length of stay after intermediate-risk, noncardiac, elective surgery OHTAC made the following recommendation[34] based on the systematic review undertaken by Health Quality Ontario: • On the basis of expert consensus, OHTAC does not recommend the use of resting echocardiography for routine preoperative screening purposes prior to noncardiac elective surgery with intermediate cardiac risk

Abbreviations: OHTAC, Ontario Health Technology Assessment Committee.

Evidence-Based Guidelines

We identified four guidelines that made recommendations relating to preoperative resting echocardiography (Table 11).[19,20,26,27]

Table 11: Existing Guidelines—Preoperative Resting Echocardiography

Guideline	Recommendation	Level of Evidence	Level of Recommendation
American College of Cardiology/ American Heart Association, 2014[26]	It is recommended that patients with clinically suspected moderate or greater degrees of valvular stenosis or regurgitation undergo preoperative echocardiography if there has been either 1. no prior echocardiography within 1 year; or 2. a significant change in clinical status or physical examination since last evaluation *Recommendations for dobutamine stress echocardiography are also provided:*	**C** Very limited populations evaluated. Only consensus opinion of experts, case studies, or standard of care	**I** Benefit >>>Risk Procedure/treatment should be performed/administered
	It is reasonable for patients with dyspnea of unknown origin to undergo preoperative evaluation of LV function	**C** Very limited populations evaluated. Only consensus opinion of experts, case studies, or standard of care	**IIa** Benefit >> Risk Additional studies with focused objectives needed. It is reasonable to perform procedure/administer treatment
	It is reasonable for patients with heart failure with worsening dyspnea or other change in clinical status to undergo preoperative evaluation of LV function	**C** Very limited populations evaluated. Only consensus opinion of experts, case studies, or standard of care	**IIa** Benefit >> Risk Additional studies with focused objectives needed. It is reasonable to perform procedure/administer treatment
	Reassessment of LV function in clinically stable patients may be considered	**C** Very limited populations evaluated. Only consensus opinion of experts, case studies, or standard of care	**IIb** Benefit ≥ Risk Additional studies with broad objectives needed; additional registry data would be helpful. Procedure/treatment may be considered
	Routine preoperative evaluation of LV function is not recommended	**B** Limited populations evaluated. Data derived from a single randomized trial or nonrandomized studies	**III** No benefit or harm *No benefit* • Procedure/test is not helpful • Treatment has no proven benefit *Harm* • Procedure/test has excess cost without benefit or is harmful • Treatment is harmful to patients
European Society of Cardiology/ European Society of Anaesthesiology,	In asymptomatic patients without signs of cardiac disease or electrocardiographic abnormalities, routine echocardiography is not recommended in patients undergoing intermediate- or low-risk surgery	**C** Consensus of opinion of the experts and/or small studies, retrospective studies, registries	**III** Evidence or general agreement that the given treatment or procedure is not useful/effective, and in some cases may be harmful

Guideline	Recommendation	Level of Evidence	Level of Recommendation
2014[27]	Clinical and echocardiographic evaluation is recommended in all patients with known or suspected VHD, who are scheduled for elective intermediate or high-risk noncardiac surgery	**C** Consensus of opinion of the experts and/or small studies, retrospective studies, registries	**I** Evidence and/or general agreement that a given treatment or procedure is beneficial, useful, effective
American Society of Anesthesiologists, 2012[19]	Pre-anesthesia cardiac evaluation may include consultation with specialists and ordering, requiring, or performing tests that range from noninvasive passive or provocative screening tests (e.g., stress testing) to noninvasive and invasive assessment of cardiac structure, function, and vascularity (e.g., echocardiogram, radionucleotide imaging, cardiac catheterization). Anesthesiologists should balance the risks and costs of these evaluations against their benefits. Clinical characteristics to consider include cardiovascular risk factors and type of surgery	**2** The literature contains noncomparative observational studies with associative (e.g., relative risk, correlation) or descriptive statistics	**B** Information from observational studies permits inference of beneficial or harmful relationships among clinical interventions and clinical outcomes
Sociedade Brasileira de Cardiologia (Brazilian Society of Cardiology), 2011[20]	Preoperative transthoracic echocardiography is recommended in: • Suspected valvular heart diseases with important clinical manifestations • Preoperative evaluation of liver transplantation	**B** Evidence in a limited group of populations from a single randomized clinical trial or nonrandomized clinical studies	**I** Benefit >>> Risk; the treatment/procedure must be indicated/administered
	Preoperative transthoracic echocardiography may help in: • Heart failure patients without prior assessment of ventricular function	**C** Evidence in very limited group of populations from consensus and experts' opinions, case reports, and series	**IIa** Benefit >> Risk; the choice for the treatment/procedure may help the patient
	Preoperative transthoracic echocardiography is recommended in: • Preoperative evaluation of bariatric surgery • Grade 3 obesity	**C** Evidence in a very limited group of populations from consensus and experts' opinions, case reports, and series	**IIb** Usefulness/efficacy is less well established by evidence/opinion
	Preoperative transthoracic echocardiography is not recommended as: • Routine for all patients	**C** Evidence in a very limited group of populations from consensus and experts' opinions, case reports, and series	**III** Risk > Benefit; the treatment/procedure must not be performed since it does not help and may be harmful for the patient

Abbreviations: LV, left ventricular; VHD, valvular heart disease.

Preoperative Cardiac Stress Testing

Choosing Wisely Recommendations

We identified four recommendations relevant to preoperative cardiac stress testing (Table 12).

Table 12: Choosing Wisely Recommendations—Preoperative Cardiac Stress Testing

Choosing Wisely	Society	Statement
Choosing Wisely Canada, 2014[30]	Canadian Society of Internal Medicine	Don't routinely perform preoperative testing (such as chest x-rays, echocardiograms, or cardiac stress tests) for patients undergoing low-risk surgeries
Choosing Wisely (USA), 2013[11]	American Society of Anesthesiologists	Don't obtain baseline diagnostic cardiac testing (transthoracic/ esophageal echocardiography) or cardiac stress testing in asymptomatic stable patients with known cardiac disease (e.g., CAD, valvular disease) undergoing low- or moderate-risk noncardiac surgery
Choosing Wisely (USA), 2013[35]	Society of Thoracic Surgeons	Patients who have no cardiac history and good functional status do not require preoperative stress testing prior to noncardiac thoracic surgery
Choosing Wisely (USA), 2013[36]	Society for Vascular Medicine	Avoid cardiovascular testing for patients undergoing low-risk surgery

Abbreviation: CAD, coronary artery disease.

Systematic Reviews and/or Health Technology Assessments

We identified one systematic review that examined the effectiveness of preoperative cardiac stress testing in patients undergoing low-risk noncardiac surgery (Table 13).[37] Further details are provided in Appendices 1 and 2.

Table 13: Systematic Review—Preoperative Cardiac Stress Testing

Author, Year	Preoperative Test	Conclusions
Health Quality Ontario, 2014[37]	Cardiac stress testing	Very low-quality evidence demonstrated that noninvasive cardiac stress tests provided modest prognostic information in patients undergoing intermediate-risk, noncardiac, elective surgery Very low-quality evidence demonstrated that noninvasive cardiac stress testing was associated with improved 1-year survival and length of hospital stay in patients undergoing intermediate-risk, noncardiac, elective surgery OHTAC made the following recommendations[38] based on the systematic review undertaken by Health Quality Ontario: • OHTAC does not recommend the routine use of noninvasive cardiac stress tests for preoperative screening purposes prior to noncardiac, intermediate-risk, elective surgery • OHTAC recommends that the selective use of these tests be guided based on patients' clinical risk factors for perioperative cardiac complications, as well as whether information from the test would inform clinical decision-making

Abbreviations: OHTAC, Ontario Health Technology Assessment Committee.

Evidence-Based Guidelines

We identified four guidelines that made recommendations relating to preoperative cardiac stress testing (Table 14).[19,20,26,27]

Table 14: Existing Guidelines—Preoperative Cardiac Stress Testing

Guideline	Recommendation	Level of Evidence	Level of Recommendation
American College of Cardiology/ American Heart Association, 2014[26]	**Exercise stress testing for myocardial ischemia and functional capacity** For patients with elevated risk and excellent functional capacity, it is reasonable to forgo further exercise testing with cardiac imaging and proceed to surgery	**B** Limited populations evaluated. Data derived from a single randomized trial or nonrandomized studies	**IIa** Benefit >> Risk Additional studies with focused objectives needed. It is reasonable to perform/administer treatment
	For patients with elevated risk and unknown functional capacity it may be reasonable to perform exercise testing to assess for functional capacity if it will change management	**B** Limited populations evaluated. Data derived from a single randomized trial or nonrandomized studies	**IIb** Benefit ≥ Risk Additional studies with broad objectives needed; additional registry data would be helpful. Procedure/treatment may be considered
	For patients with elevated risk and moderate to good (≥ 4 to 10 METs) functional capacity, it may be reasonable to forgo further exercise testing with cardiac imaging and proceed to surgery	**B** Limited populations evaluated. Data derived from a single randomized trial or nonrandomized studies	**IIb** Benefit ≥ Risk Additional studies with broad objectives needed; additional registry data would be helpful. Procedure/treatment may be considered
	For patients with elevated risk and poor (< 4 METs) or unknown functional capacity it may be reasonable to perform exercise testing with cardiac imaging to assess for myocardial ischemia if it will change management	**C** Very limited populations evaluated. Only consensus opinion of experts, case studies, or standard of care	**IIb** Benefit ≥ Risk Additional studies with broad objectives needed; additional registry data would be helpful. Procedure/treatment may be considered
	Routine screening with noninvasive stress testing is not useful for low-risk noncardiac surgery	**B** Limited populations evaluated. Data derived from a single randomized trial or nonrandomized studies	**III** No benefit or harm *No benefit* • Procedure/test is not helpful • Treatment has no proven benefit *Harm* • Procedure/test has excess cost without benefit or is harmful • Treatment is harmful to patients
	Noninvasive pharmacological stress testing before noncardiac surgery It is reasonable for patients at elevated risk for noncardiac surgery with poor functional capacity (< 4 METs) to undergo noninvasive pharmacological stress testing (either dobutamine stress echocardiogram or pharmacological stress myocardial perfusion imaging) if it will change management	**B** Limited populations evaluated. Data derived from a single randomized trial or nonrandomized studies	**IIa** Benefit >> Risk Additional studies with focused objectives needed. It is reasonable to perform/administer treatment

Guideline	Recommendation	Level of Evidence	Level of Recommendation
	Routine screening with noninvasive pharmacological stress testing is not useful for patients undergoing low-risk noncardiac surgery	**B** Limited populations evaluated. Data derived from a single randomized trial or nonrandomized studies	**III** No benefit or harm *No benefit* • Procedure/test is not helpful • Treatment has no proven benefit *Harm* • Procedure/test has excess cost without benefit or is harmful • Treatment is harmful to patients
European Society of Cardiology/ European Society of Anaesthesiology, 2014[27]	Imaging stress testing may be considered before high- or intermediate-risk surgery in [asymptomatic] patients with one or two clinical risk factors and poor functional capacity (< 4 METs)	**C** Consensus of opinion of the experts and/or small studies, retrospective studies, registries	**IIb** Usefulness/efficacy is less well established by evidence/opinion
	Imaging stress testing is not recommended before low-risk surgery, regardless of the patient's clinical risk	**C** Consensus of opinion of the experts and/or small studies, retrospective studies, registries	**III** Evidence or general agreement that the given treatment or procedure is not useful/effective, and in some cases may be harmful
American Society of Anesthesiologists, 2012[19]	Pre-anesthesia cardiac evaluation may include consultation with specialists and ordering, requiring, or performing tests that range from noninvasive passive or provocative screening tests (e.g., stress testing) to noninvasive and invasive assessment of cardiac structure, function, and vascularity (e.g., echocardiogram, radionucleotide imaging, cardiac catheterization). Anesthesiologists should balance the risks and costs of these evaluations against their benefits. Clinical characteristics to consider include cardiovascular risk factors and type of surgery	**2** The literature contains noncomparative observational studies with associative (e.g., relative risk, correlation) or descriptive statistics	**B** Information from observational studies permits inference of beneficial or harmful relationships among clinical interventions and clinical outcomes
Sociedade Brasileira de Cardiologia (Brazilian Society of Cardiology), 2011[20]	Stress myocardial perfusion scintigraphy or echocardiography during the preoperative period may help in: • Patients with intermediate risk for complications and vascular surgery scheduled	**B** Evidence in a limited group of populations from single randomized clinical trial or nonrandomized clinical studies	**IIa** Benefit >> Risk; the choice for the treatment/procedure may help the patient
	The usefulness/efficacy of stress myocardial perfusion scintigraphy or echocardiography during the preoperative period is less well established in: • Patients with intermediate risk for complications and intermediate-risk surgery scheduled • Patients with low functional capacity with intermediate-and high-risk surgeries scheduled	**C** Evidence in very limited group of populations from consensus and experts' opinions, case reports, and series	**IIb** Usefulness/efficacy is less well established by evidence/opinion

Abbreviations: MET, metabolic equivalent.

SUMMARY

The evidence on preoperative testing (laboratory testing, chest x-rays, electrocardiograms, resting echocardiography, and cardiac stress testing) for asymptomatic patients who are having low- to intermediate-risk noncardiac surgery was limited in both quantity and quality, but it consistently showed no benefit. Clinical guidelines recommend that health care providers consider patients' clinical risk factors when deciding whether or not to use preoperative testing.

The evidence could not be generalized because of specific populations and mixed interventions. Often, investigators looked at specific elective surgeries that were thought to be representative of other low- to intermediate-risk surgeries. Common use of a combination of preoperative tests also made it difficult to determine the effect of individual preoperative tests of interest.

APPENDICES

Appendix 1: Included Systematic Reviews and Health Technology Assessments—Description

Author, Year	Objective(s)	Search Time Frame	Population	Intervention(s)	Comparator(s)	Outcome(s)

Agency for Healthcare Research and Quality, 2014[1]	To review the important issues relating to preoperative testing, provide an overview of the most significant studies published on the subject, examine the cost implications of unnecessary testing, and examine strategies to optimize preoperative testing	Inception to July 2013	Adults (≥ 18 years old) and children undergoing surgical procedures requiring either anesthesia or sedation	• Electrolytes (e.g., sodium, potassium)
				• Kidney function tests (e.g., creatinine, glomerular filtration rate)
				• Liver function tests (or other components of a "complete metabolic panel")
				• Glycemia measures (e.g., glucose, hemoglobin A1c)
				• Blood counts (e.g., hemoglobin, hematocrit, white blood cells, platelets)
				• Bleeding and coagulation tests (e.g., prothrombin time, bleeding test)
				• Hemoglobinopathy tests (e.g., sickle cell)
				• Urinalysis
				• Pregnancy tests
				• Chest radiography
				• Electrocardiograms
				• Cardiac stress tests
				• Basic echocardiogram
				• Pulmonary function tests
					• No preoperative testing
					• Ad hoc testing
					• Per-protocol testing
					• A different panel of routine tests
					• Testing conducted in a different setting or by a different type of clinician
					• Testing done at different presurgery time points
						• Clinical and other patient-centred outcomes
						  ○ Procedure or anesthesia delay
						  ○ Procedure cancellation
						  ○ Perioperative clinical outcomes (e.g., mortality, surgical complications)
						  ○ Patient quality of life
						  ○ Patient satisfaction
						  ○ Patient resources, including time and lost work
						  ○ Unplanned hospital admission or readmission within 30 days
						  ○ Change in disposition of care (e.g., unplanned intensive care unit admission)
						  ○ Length of hospital stay
						  ○ Other resource utilization, including unplanned follow-up tests or procedures
						• Intermediate outcome
						  ○ Changes to perioperative patient management (other than procedure delay or cancellation)
						• Unnecessary or inappropriate procedure or anesthesia delays
						• Unnecessary or inappropriate procedure cancellation
						• Harms from testing or from interventions that resulted from test results
						• "Unnecessary" follow-up tests or procedures

Author, Year	Objective(s)	Search Time Frame	Population	Intervention(s)	Comparator(s)	Outcome(s)
Health Quality Ontario, 2014[37]	To determine the prognostic accuracy of preoperative, noninvasive, cardiac stress testing for noncardiac elective surgery with intermediate cardiac risk	January 1, 2003, and August 15, 2013	Adult patients scheduled to undergo intermediate-risk, noncardiac, elective surgery	Noninvasive cardiac stress tests	No testing	• Mortality • Myocardial infarction
Health Quality Ontario, 2014[33]	To determine the prognostic accuracy of preoperative resting echocardiography for noncardiac elective surgery with intermediate cardiac risk	January 1, 2003, and August 12, 2013	Adult patients scheduled to undergo intermediate-risk, noncardiac, elective surgery	Resting echocardiography	No comparison	• Mortality • Length of stay
Johansson et al, 2013[12]	To determine whether preoperative laboratory testing or preoperative tests of the respiratory system lead to changes in clinical management, or do they reduce peri- and postoperative complications in unselected patients undergoing elective, noncardiac surgery	January 2001 to February 2011	Adults (≥ 18 years old) undergoing elective surgery, routine or indicated testing, noncardiac surgery	Laboratory tests: • Complete blood count • Hemostasis • Blood gases • Renal function • Liver function • Electrolytes • C-reactive protein • Pregnancy screening • Urine analysis • A set of any of these procedures Tests of the respiratory system: • Spirometry • Chest x-ray • Test grid (comprising a set of any of the procedures above)	No testing	• Peri- and postoperative mortality • Morbidity (including complications and adverse events) • Change in preoperative clinical management (e.g., prolonged preoperative hospital stay, cancellation or delay in patient's surgery, preoperative change in treatment)

Author, Year	Objective(s)	Search Time Frame	Population	Intervention(s)	Comparator(s)	Outcome(s)
Czoski-Murray et al, 2012[13]	To estimate the clinical effectiveness and cost-effectiveness of routine preoperative testing of CBC, electrolytes and renal function, and pulmonary function testing in adult patients classified as ASA grades 1 and 2 undergoing elective minor (grade 1) or intermediate (grade 2) surgical procedures	1980 to May 2009	Adult patients classified as ASA grades 1 and 2 undergoing elective minor (grade 1) or intermediate (grade 2) surgical procedures	Routine preoperative testing of: • CBC (including hemoglobin concentration, hematocrit, platelet count, and white blood cell count) • Electrolytes and renal function (including sodium, potassium, urea, and creatinine) • Pulmonary function tests (including some or all of spirometry, blood gas analysis, measurement of respiratory mechanics, measurement of transfer function, and exercise testing of respiratory system)	No routine preoperative testing	• Abnormal test results • Changes in management following abnormal test results in patients whose preoperative clinical examinations were normal • Adverse events possibly related to the test result • Adverse events probably or possibly caused by the process of testing • All-cause mortality
Keay et al, 2012[14]	To investigate the evidence for reductions in medical adverse events through preoperative medical testing, and to estimate the average cost of performing routine medical testing	Up to January 2012	Individuals who required cataract surgery due to age-related cataract (participants with congenital cataract were excluded)	• Routine presurgical, medical testing (e.g., electrocardiography, chest x-ray, complete blood counts, and various serum measurements)	• No routine preoperative testing • Selective preoperative testing	• Rate of medical adverse events that occurred within 7 days of surgery and had a plausible causal relationship to the surgery • Cost-effectiveness of medical testing • Rate at which surgery was postponed or cancelled on the basis of the medical screening • Cost of rescheduling surgery and delay in receiving visual rehabilitation • Proportion of patients who underwent a change in the clinical management of their underlying medical condition due to findings on routine preoperative testing • Ocular adverse events

Abbreviations: ASA, American Society of Anesthesiologists; CBC, complete blood count.

Appendix 2: Included Systematic Reviews and Health Technology Assessments—Results

Author, Year	Conclusion(s)
Agency for Healthcare Research and Quality, 2014[1]	*Cataract surgery* • Three RCTs of cataract surgery—two with low risk of bias, one with moderate risk of bias—compared routine versus no (or ad hoc) preoperative testing with ECG, basic metabolic panel, and CBC for patients undergoing cataract surgery • The studies were clinically similar to each other and consistent; there was a high strength of evidence of no clinically important difference in complication rates (RR, 0.99, 95% CI, 0.86–1.14) • Overall, there was no evidence of different outcomes related to routine preoperative testing *General or various surgeries* • Identified one RCT and five observational studies • One low-risk-of-bias RCT and four high-risk-of-bias nonrandomized studies compared routine testing (two studies) or per-protocol testing (three studies) with ad hoc testing, using ECG, chest x-ray, basic and extended metabolic panels, CBC, hemostasis tests, and urinalysis in adult patients undergoing a broad range of elective surgeries. A sixth study compared time periods when patients were to receive either routine testing (during a retrospective period) or per-protocol testing (during a prospective period) with a large number of tests • There was insufficient evidence regarding perioperative complications or of a clinically significant difference in the rate of perioperative death • There was also insufficient evidence regarding other specific outcomes, including return to the operating room, prolonged hospital stay, or surgical cancellation or delay • No trial reported on quality of life or satisfaction, change in anesthesia or procedure plan, or resource utilization • A single high-risk-of-bias nonrandomized study provided insufficient evidence regarding the comparison of routine and per-protocol testing • No trial addressed harms of routine preoperative testing *Orthopaedic surgery* • One retrospective nonrandomized study evaluated preoperative testing in adults undergoing various elective orthopaedic surgeries • There was insufficient evidence regarding the comparison of routine versus per-protocol preoperative testing in adults undergoing orthopaedic surgery • A single high-risk-of-bias retrospective nonrandomized study found no difference in the rate of unplanned hospital admissions within 30 days of surgery
Health Quality Ontario, 2014[37]	• Very low-quality evidence demonstrated that noninvasive cardiac stress tests provide modest prognostic information in patients undergoing intermediate-risk, noncardiac, elective surgery • Very low-quality evidence demonstrated that noninvasive cardiac stress testing is associated with improved 1-year survival and length of hospital stay in patients undergoing intermediate-risk, noncardiac, elective surgery *Related OHTAC 2014 recommendation*[38] • OHTAC does not recommend the routine use of noninvasive cardiac stress tests for preoperative screening purposes prior to noncardiac, intermediate-risk, elective surgery • OHTAC recommends that the selective use of these tests be guided based on patients' clinical risk factors for perioperative cardiac complications, as well as whether information from the test would inform clinical decision-making
Health Quality Ontario, 2014[33]	• No studies were identified that examined the prognostic accuracy of resting echocardiography • Very low-quality evidence demonstrated that resting echocardiography is not associated with improved survival or decreased length of stay after intermediate-risk, noncardiac, elective surgery *Related OHTAC 2014 recommendation*[34] • On the basis of expert consensus, OHTAC does not recommend the use of resting echocardiography for routine preoperative screening purposes prior to noncardiac elective surgery with intermediate cardiac risk

Author, Year	Conclusion(s)
Johansson et al, 2013[12]	*Test grids* • Identified three RCTs • There was no evidence derived from high-quality studies that supported routine preoperative testing in healthy adults undergoing noncardiac surgery • Preoperative testing before cataract surgery did not affect outcome parameters • Preoperative medical testing neither reduced the rate of intra- or postoperative ophthalmic complications (RR, 0.73, 95% CI, 0.29–1.78 and RR, 0.83, 95% CI, 0.26–2.72, respectively) nor the rate of intraoperative systemic adverse events (RR, 1.0, 95% CI, 0.25–3.98) when compared with no testing • The cumulative rate of medical events was 9.6% in the routine testing group compared with 9.7% (*P* = 0.923) in the selective testing group *Pulmonary evaluation (spirometry, chest x-ray, blood gases)* • Identified 12 observational studies • There was no valid evidence supporting routine (unselective) spirometry in asymptomatic patients • There was no valid evidence supporting routine (unselective) chest x-ray • There was no evidence to support routine (unselective) preoperative blood gas analysis in patients without history of pulmonary disease *Hemoglobin and hematocrit* • Identified 39 observational studies • None of the studies offered a controlled comparison between preoperative testing and no testing. Thus, the efficacy of the diagnostic intervention could not be estimated directly *White blood cell count and C-reactive protein testing* • Identified eight observational studies • There was no valid evidence supporting routine (unselective) preoperative white blood cell or C-reactive protein testing in asymptomatic patients *Hemostasis testing* • Identified nine observational studies • No study investigated the association of hemostasis testing and changes in clinical management • There was no valid evidence suggesting that routine preoperative hemostasis testing will lead to a change in clinical management or outcome in asymptomatic patients *Renal function tests, electrolytes, and urine analysis* • Identified 25 observational studies • There was no evidence that justified routine testing for renal function, electrolytes, and urine analysis in asymptomatic subjects without a history of renal disease or electrolyte disorder *Liver function testing* • Identified seven observational studies • There was no valid evidence supporting routine (unselective) liver tests in asymptomatic patients

Author, Year	Conclusion(s)
Czoski-Murray et al, 2012[13]	*Complete blood count* • Identified two prospective case series and three retrospective case series • The evidence relating to the value of routine preoperative CBCs for ASA grade 1 or 2 patients undergoing elective minor to intermediate surgery was limited in both quantity and quality • This limited evidence suggested that the proportion of patients with an abnormal result in any component of the complete blood test was low (range 0.8%–3.0%), and the proportion with both an abnormal test result and a consequent change in clinical management was lower (range 0%–1.9%) • No deaths were specifically reported in patients with abnormal test results *Electrolytes and renal function* • Identified one prospective case series and three retrospective case series • The evidence relating to the value of routine electrolytes and renal function for ASA grade 1 or 2 patients undergoing elective minor to intermediate surgery was limited in both quantity and quality • Only one study reported the proportion of patients with an abnormal result in any component of the test; this figure was low, at 0.7%, and did not lead to any change in clinical management • No deaths were specifically reported in patients with abnormal test results *Pulmonary function tests* • Identified one pseudo-randomized trial • Evidence relating to the value of routine pulmonary function tests for ASA grade 1 or 2 patients undergoing elective minor to intermediate surgery was extremely limited, being restricted to 84 patients in the control arm of a RCT conducted for another purpose • The proportion of patients with an abnormal result was relatively low, at 4.8%, and did not lead to a change in management in any of the patients
Keay et al, 2012[14]	*Cataract surgery* • Identified three RCTs • Preoperative medical testing did not reduce the rate of intraoperative (OR, 1.02, 95% CI, 0.85–1.22) or postoperative medical adverse events (OR, 0.96, 95% CI, 0.74–1.24) compared to selective or no testing • No significant differences were reported in the rate or types of ocular adverse events between the pretesting group compared to the selective or no testing group, for either intraoperative and postoperative events • There was no difference in the rate of cancellation between those with routine preoperative medical testing and those with no or limited preoperative testing • The rate of postponement or cancellation of surgeries for medical reasons was reported in only one study and the rate was similar in the two groups: 2.5% in the no testing group and 2.3% in the routine testing group • A rate of change in surgical management was not measured in any of the studies identified in this review other than cancellation of surgery

Abbreviations: ASA, American Society of Anesthesiologists; CBC, complete blood count; CI, confidence interval; ECG, electrocardiogram; OHTAC, Ontario Health Technology Advisory Committee; OR, odds ratio; RCT, randomized controlled trial; RR, relative risk.

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